Fermilab

Particle Physics Division
Mechanical Department Engineering Note

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Project: Nova

Title: Epoxy Thickness

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Key Words: NOvA, epoxy

Applicable Codes:

Abstract Summary:

The following analyzes the thickness of cells of epoxy used to hold the plains of the NOvA detectors together, as a function of the proximity of the vacuum lifts used.

Discussion/Summary (SHEET 1)

The NOvA detector extrusions were pressed together with epoxy between two sheets of HDPE, and the epoxy sheet was removed for thickness analysis. There were two sheets made; one with the extrusions pressed together and released by vacuum lifts, and one where the vacuum lifts held the extrusion down squeezing the epoxy for an hour. The epoxy sheets are separated into 16 cell sections labeled A-Z in length, and is 32 cells deep. The top layer of HDPE was removed; with sections T, U, and V, along with the locations of vacuum lift contact traced directly onto the epoxy cells. This makes the grid studied from (0,0) (lower left) to (47,31) (upper right).

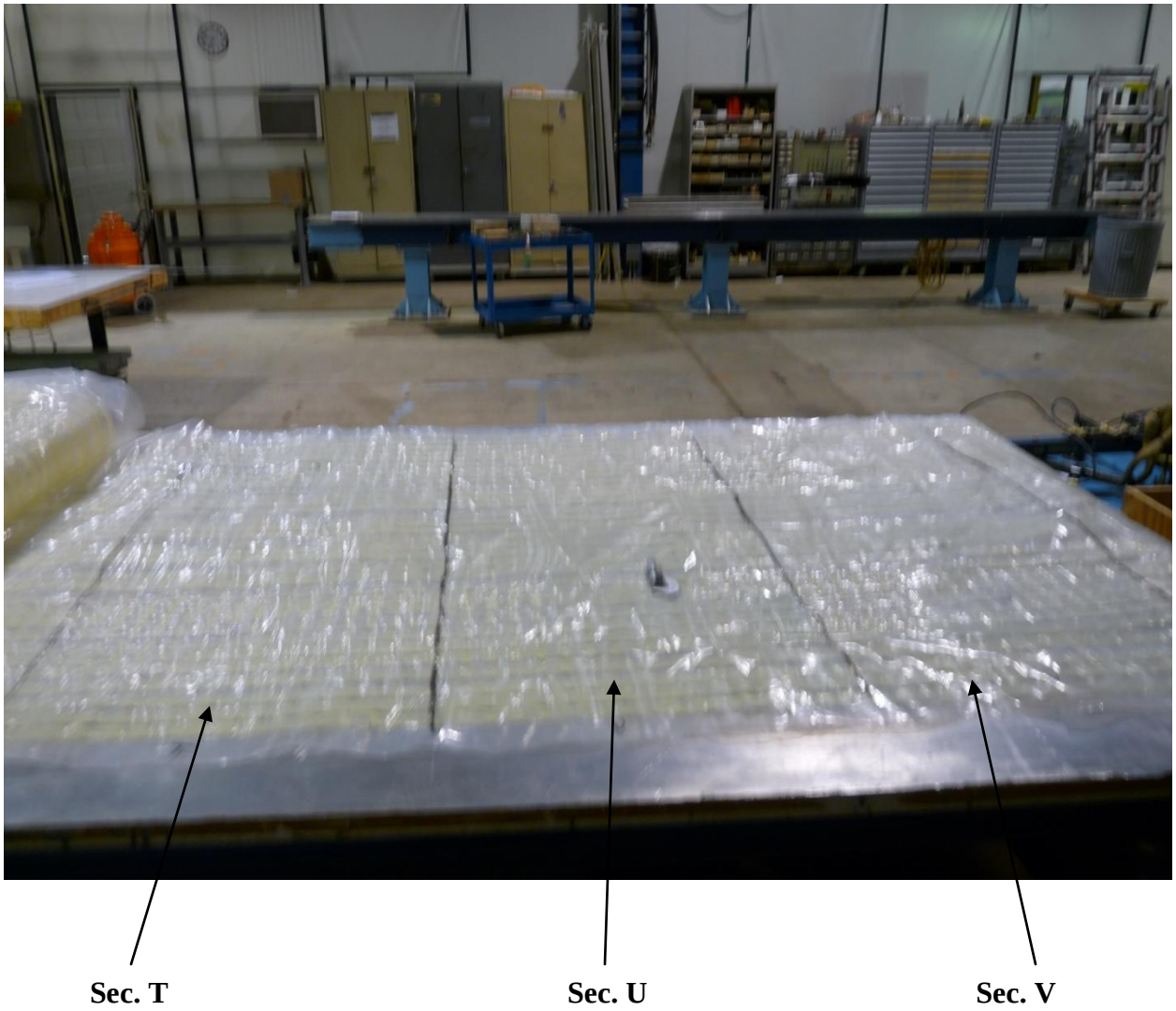
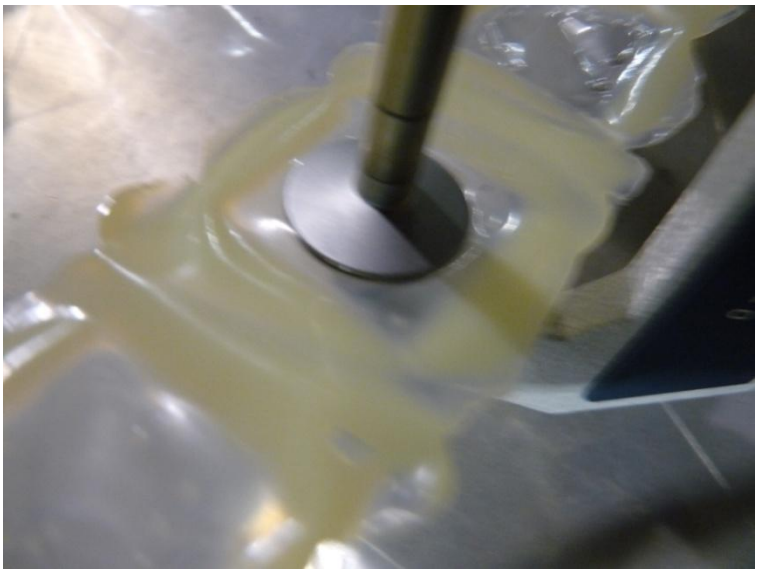


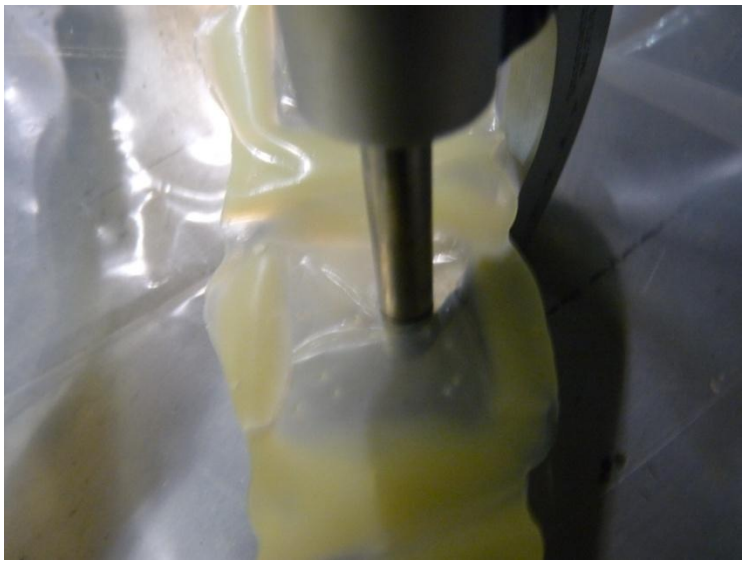
Figure: Three sections where thickness measurements were taken, with the lower left corner being the origin (0,0). Sections T and V contain two vacuum lift points each described below.

Measurements (sheet 1 and 2)

Measurements were taken on every cell center using a micrometer with an appropriately small contact surface (seen below, bottom), due to the generally increasing thickness the more outward on the cell the measurement was taken, and also small bumps or deformations. When another micrometer with a much larger contact surface (seen below, top) was used for data comparison, the thicknesses were read at nearly double the actual center thickness due to edges and small bumps making this data extraneous. Also worth noting; measurements were taken aside major deformations (most likely due to wrinkles in the HDPE sheets) that may have existed within individual cells as to come as close to true thickness as possible.



→Contact area too large; hangs on to thicker edges giving false thicknesses



→Much smaller contact area gives truer center thickness

Micrometer used

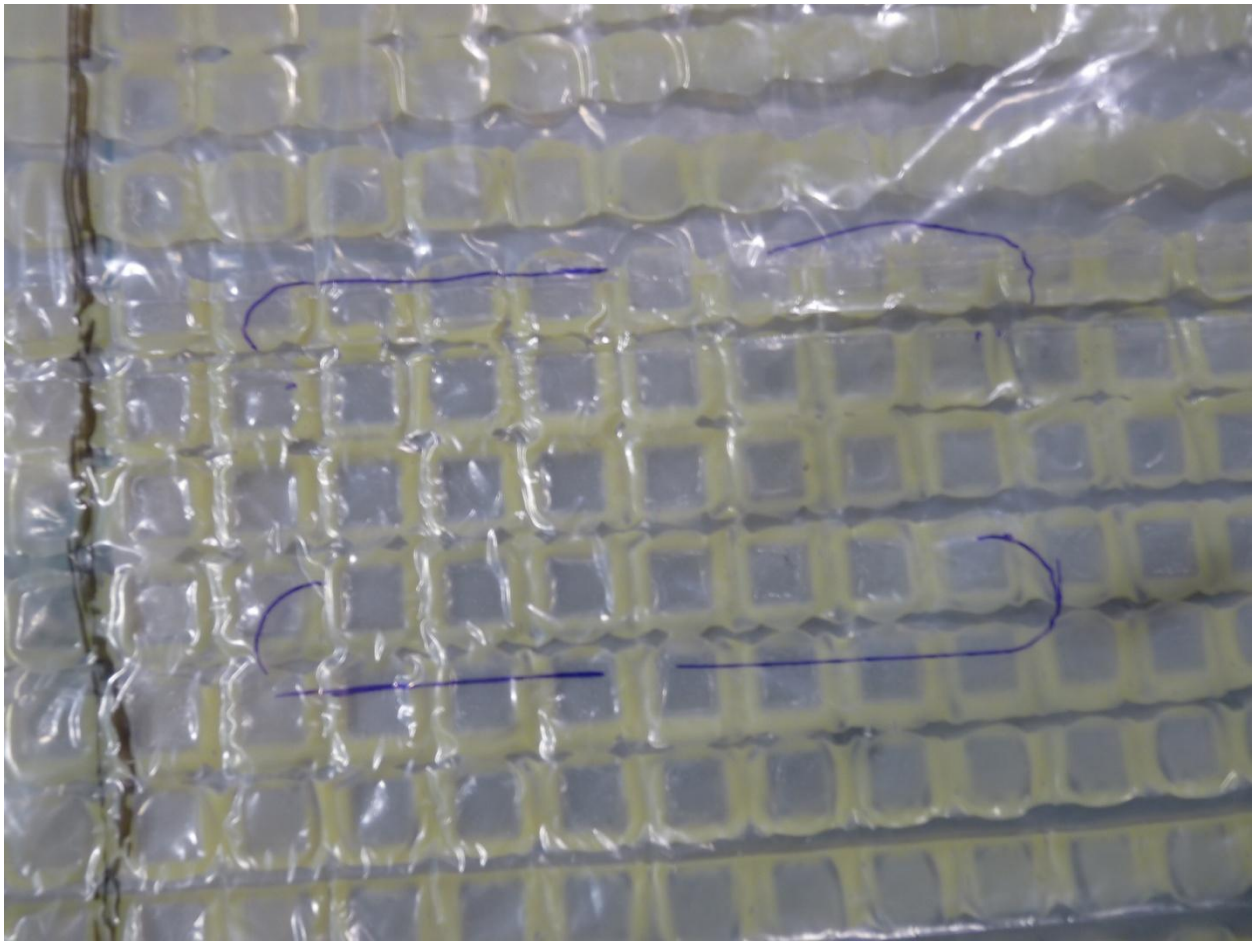


Figure: Vacuum lift point located in section V.

Vacuum lift locations Section T:	*Lift 1 Area*	*Lift 2 Area*
	(0,6) → (7,6)	(0,22) → (7,22)
	(0,10) → (7,10)	(0,26) → (7,26)
Vacuum lift locations Section V:	*Lift 3 Area*	*Lift 4 Area*
	(33,6) → (41,6)	(33,22) → (41,22)
	(33,10) → (41, 10)	(33,26) → (41,26)

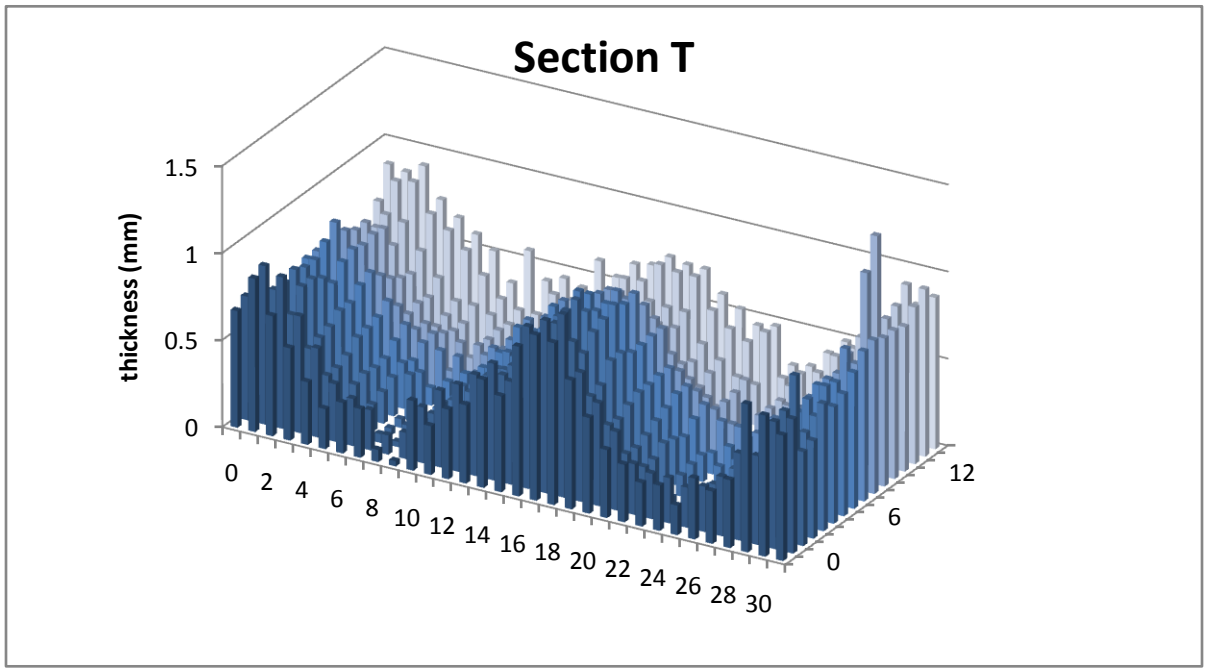


Figure: 3-D representation of Section T with each bar signifying the thickness of an epoxy cell; containing two vacuum lift points listed above.

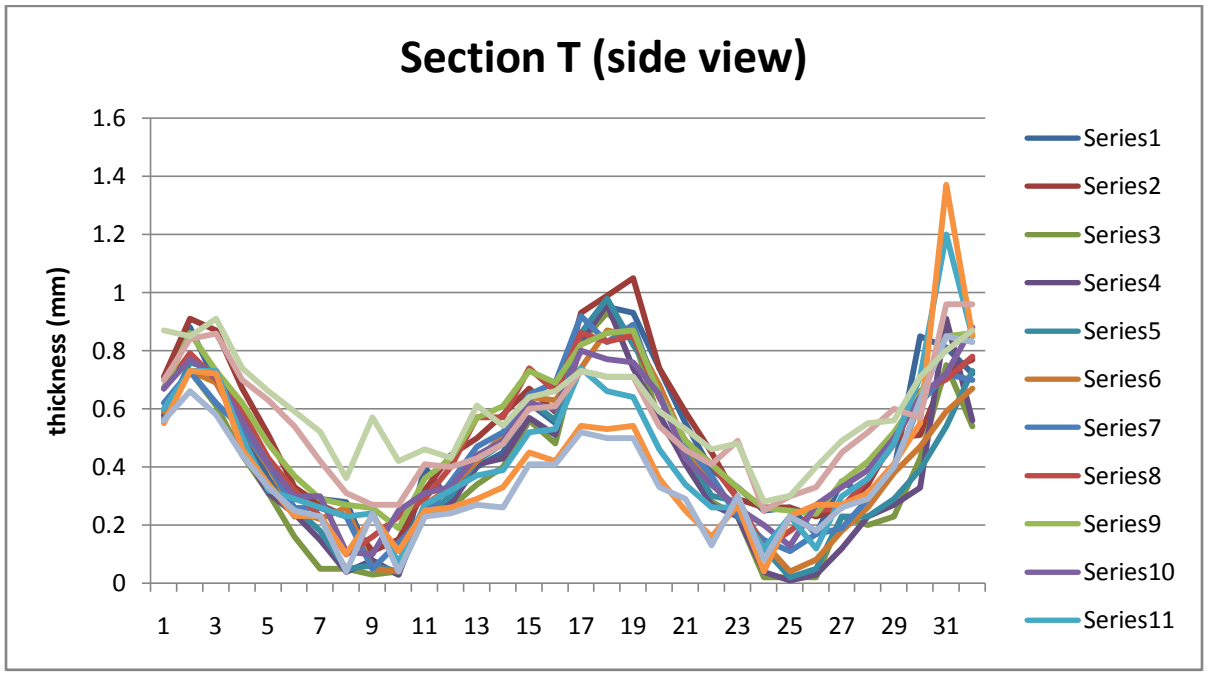


Figure: Side view of Section T showing the trend in thickness related to depth

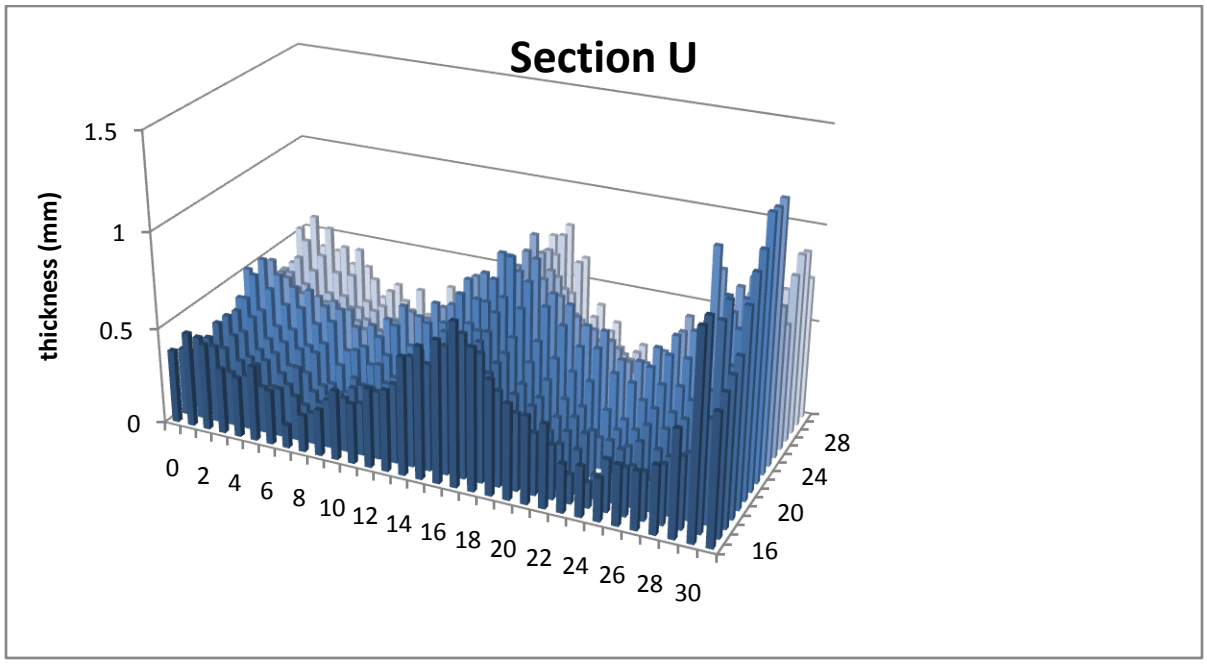


Figure: 3-D representation of Section U with each bar signifying the thickness of an epoxy cell; containing no vacuum lift points, but maintaining the general shape as if it were.

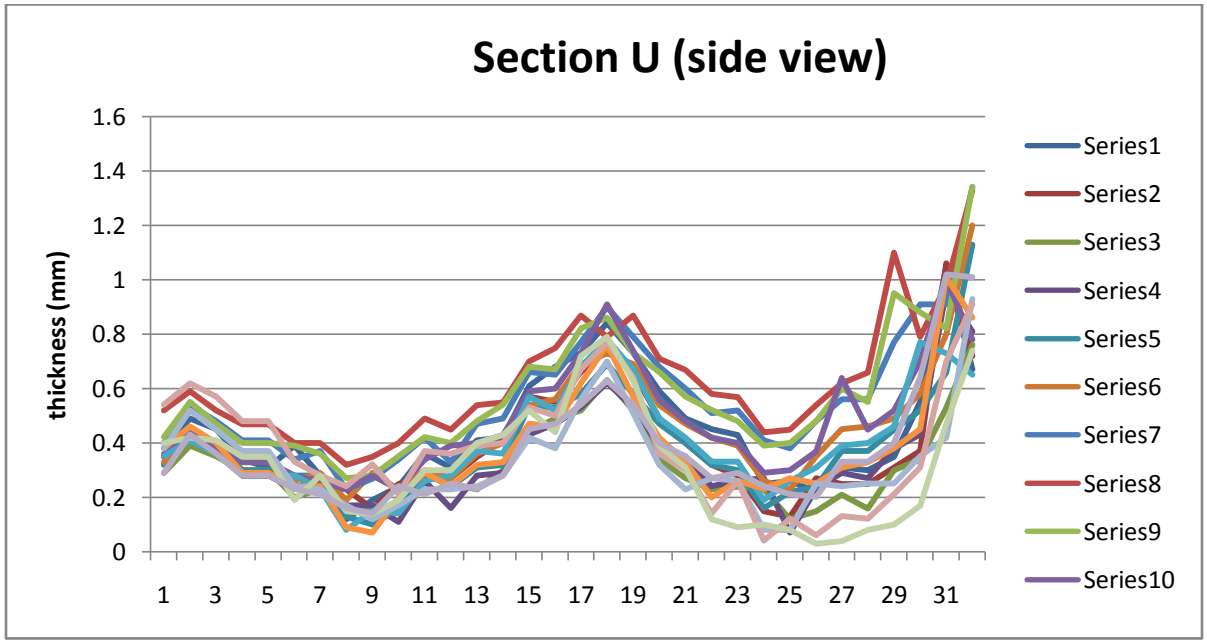


Figure: Side view of Section U showing the trend in thickness related to depth

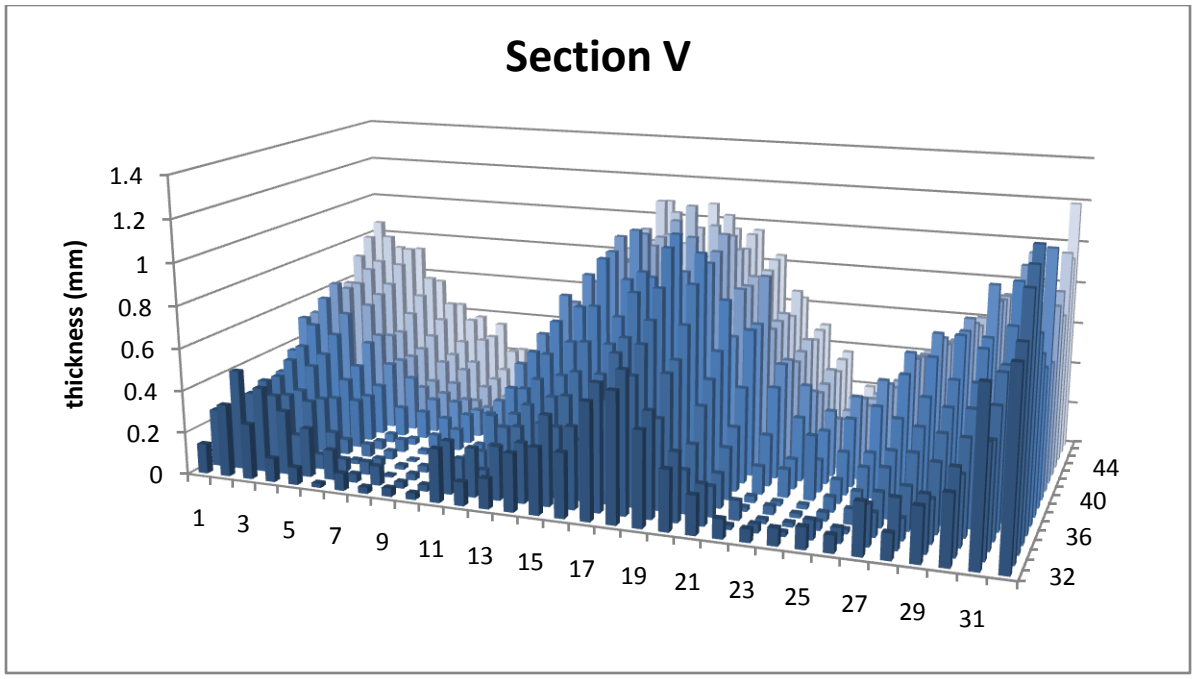


Figure: 3-D representation of Section V with each bar signifying the thickness of an epoxy cell; containing two vacuum lift points listed above.

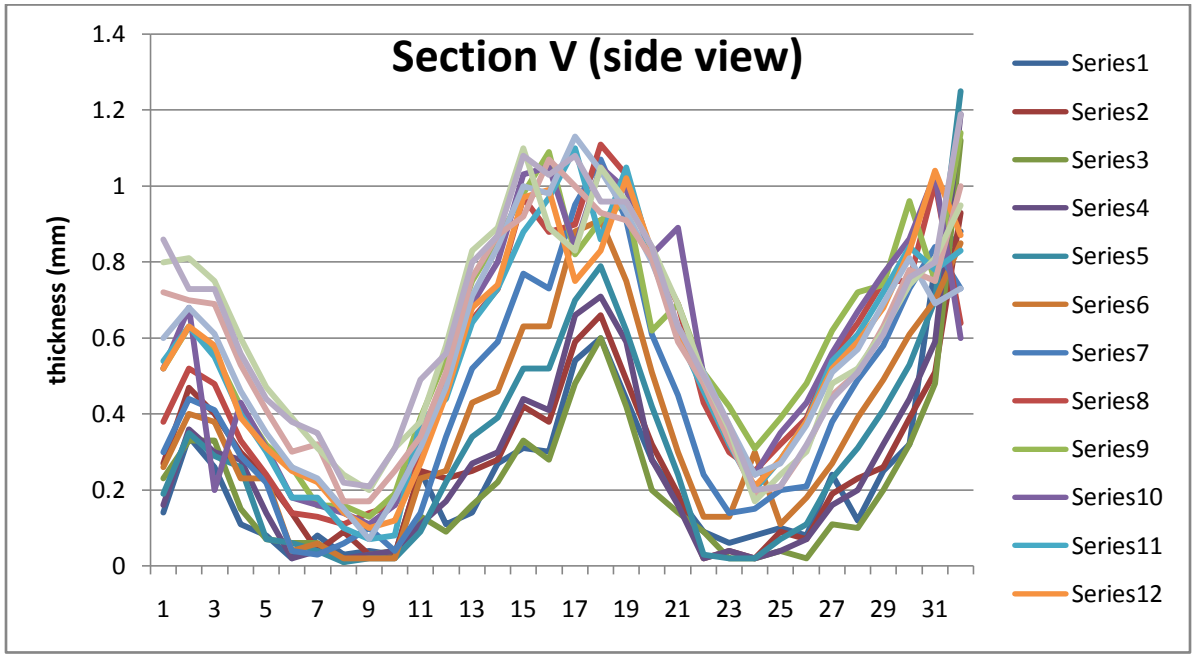


Figure: Side view of Section V showing the trend in thickness related to depth

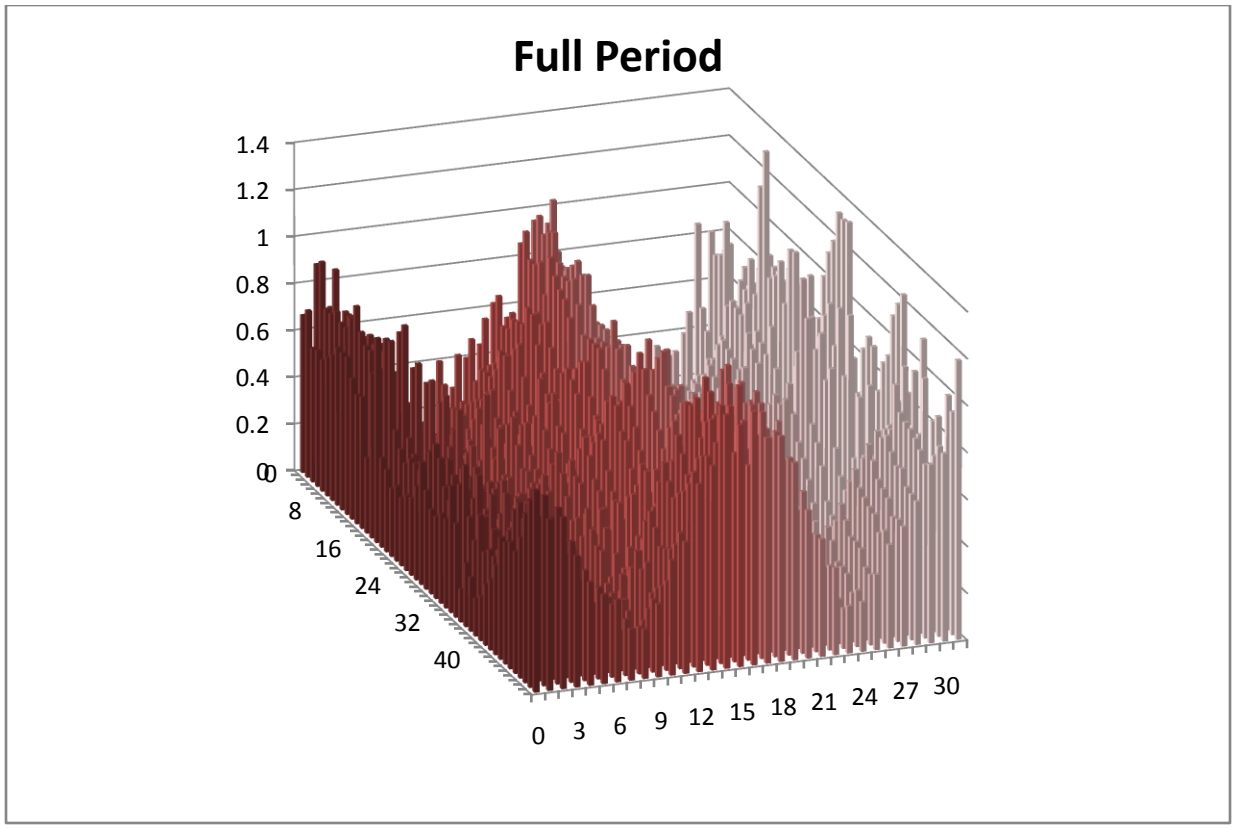


Figure: 3-D representation of all three sections

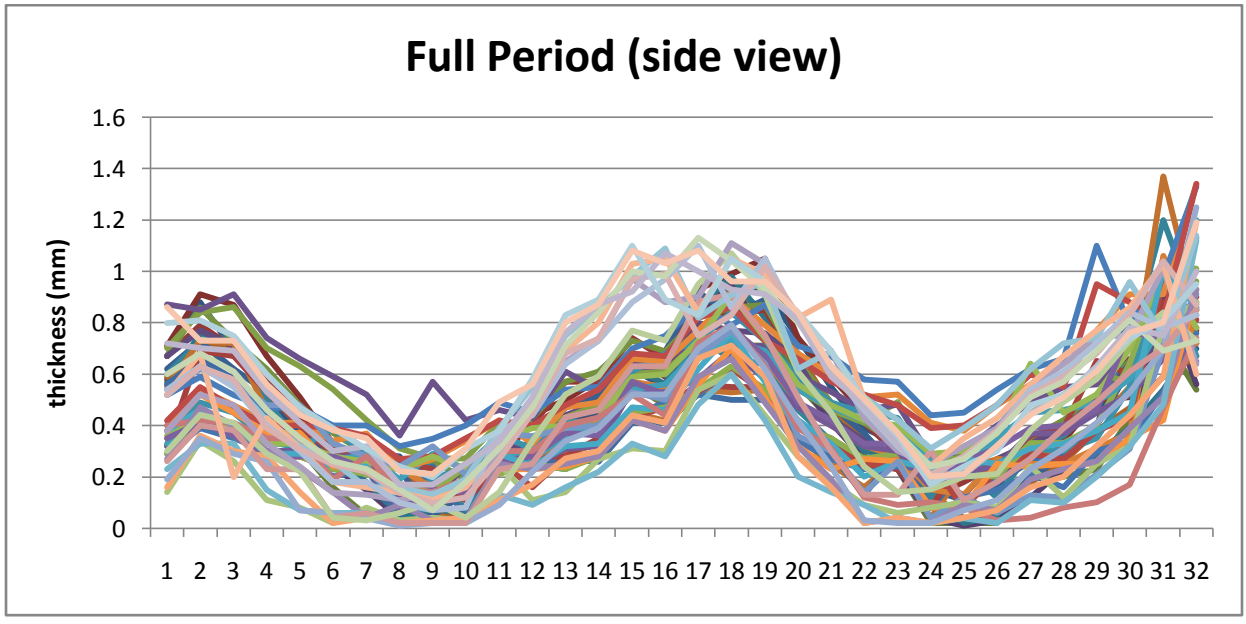


Figure: Side view of all three sections showing the trend in thickness related to depth

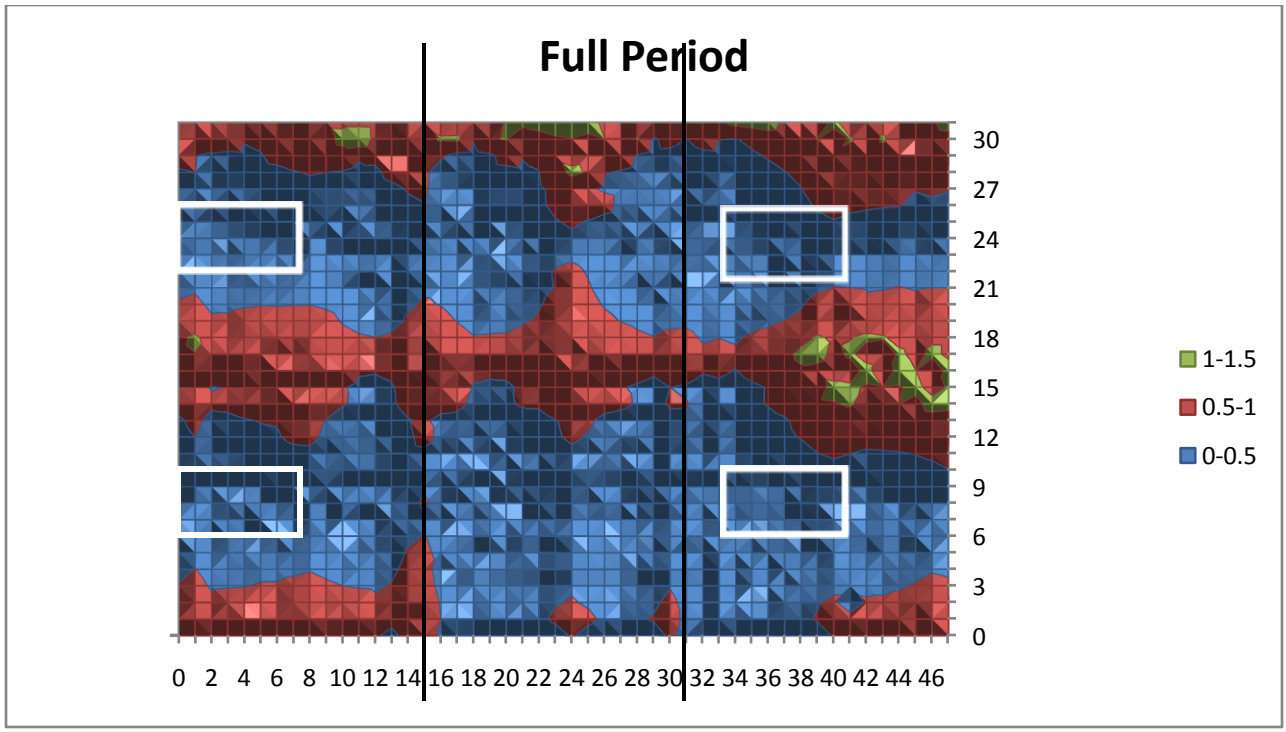


Figure: Overhead view of all three sections with vacuum lift points highlighted in white rectangles.

Conclusions sheet 1

The thickness of the cells seems to vary more clearly by row rather than by column. The cells are thinnest in rows closest in proximity to the lift points, and thickest in rows furthest from the lift points. This allows thicker sections of epoxy to form along the center and the edges of the sheet. The optimum thickness of the epoxy is about 12 mils, or 0.3048 mm.

-Average thickness of cells in full period studied: 0.4436 mm

-Standard deviation of cells in full period studied: 0.26 mm

(Very high, so averages will be broken down by sections of rows related to lift positions)

-Average thickness: rows 3→13: 0.298 mm

-Average thickness: rows 1→3, 13→21, and 28→31: 0.612 mm

-Average thickness: rows 22→28: 0.303 mm

→ Average thickness in lift affected row sections is right around the optimum

➔ **35% of the total cells are close to optimum thickness, between 0.2 mm – 0.4 mm.**

Discussion/Summary Sheet 2

Sheet two was made identically to sheet 1, but is 28 rows deep rather than 32. Each section remains 16 cells long. We will hypothesize which was pressed for an hour based on results

Vacuum lift locations Section 20:	*Lift 1 Area*	*Lift 2 Area*
	(0,2) → (8,2)	(0,18) → (8,18)
	(0,6) → (8,6)	(0,22) → (8,22)

Vacuum lift locations Section22:	*Lift 3 Area*	*Lift 4 Area*
	(34,2) → (42,2)	(34,18) → (42,18)
	(34,6) → (42,6)	(34,22) → (42,22)

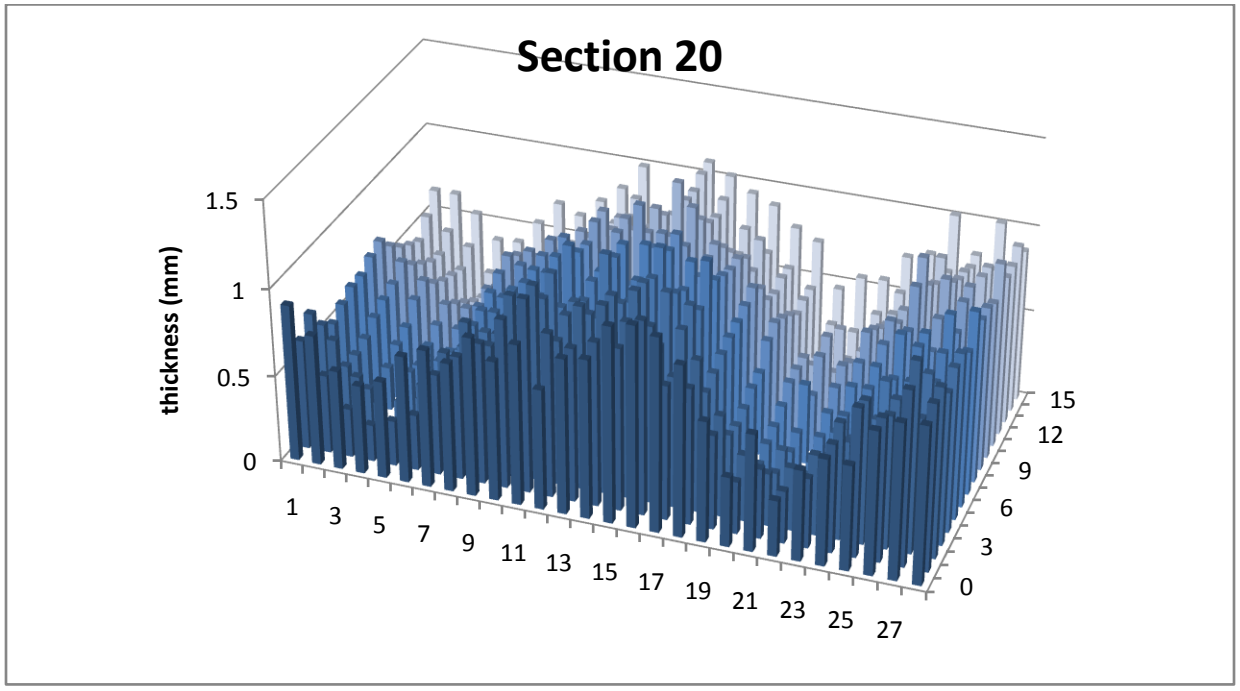


Figure: 3-D representation of Section 20 with each bar signifying the thickness of an epoxy cell; containing two vacuum lift points listed above.

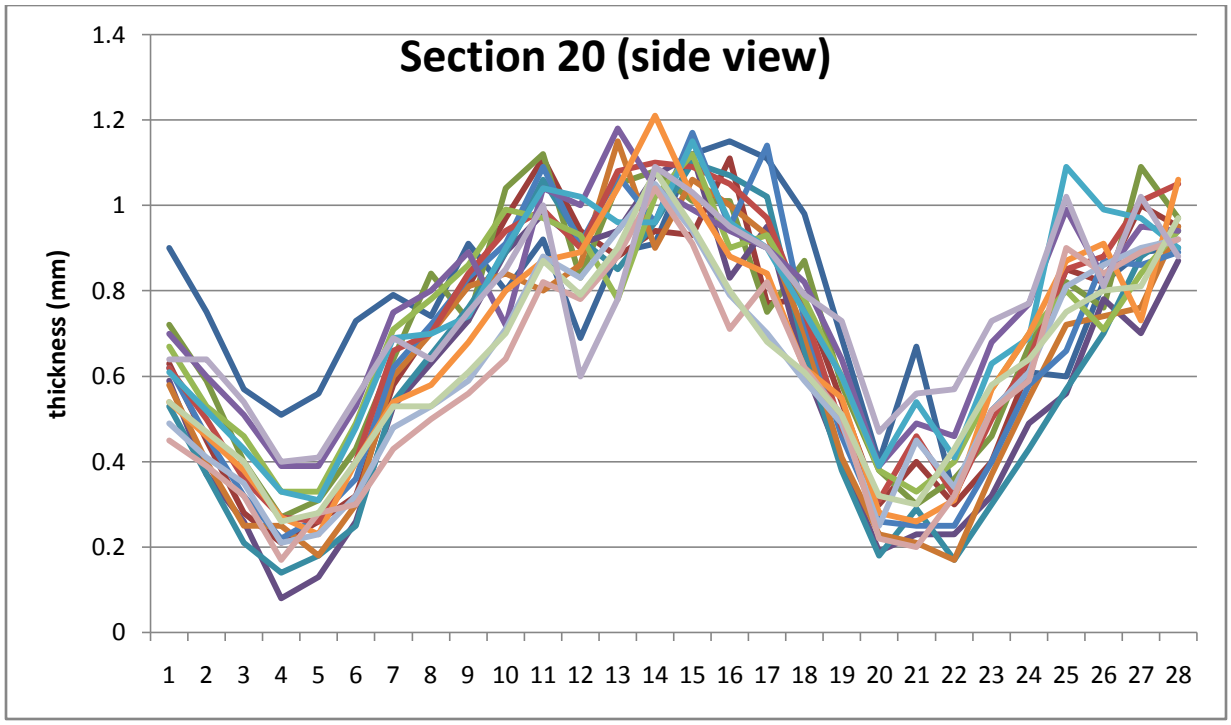


Figure: Side view of Section 20 showing the trend in thickness related to depth

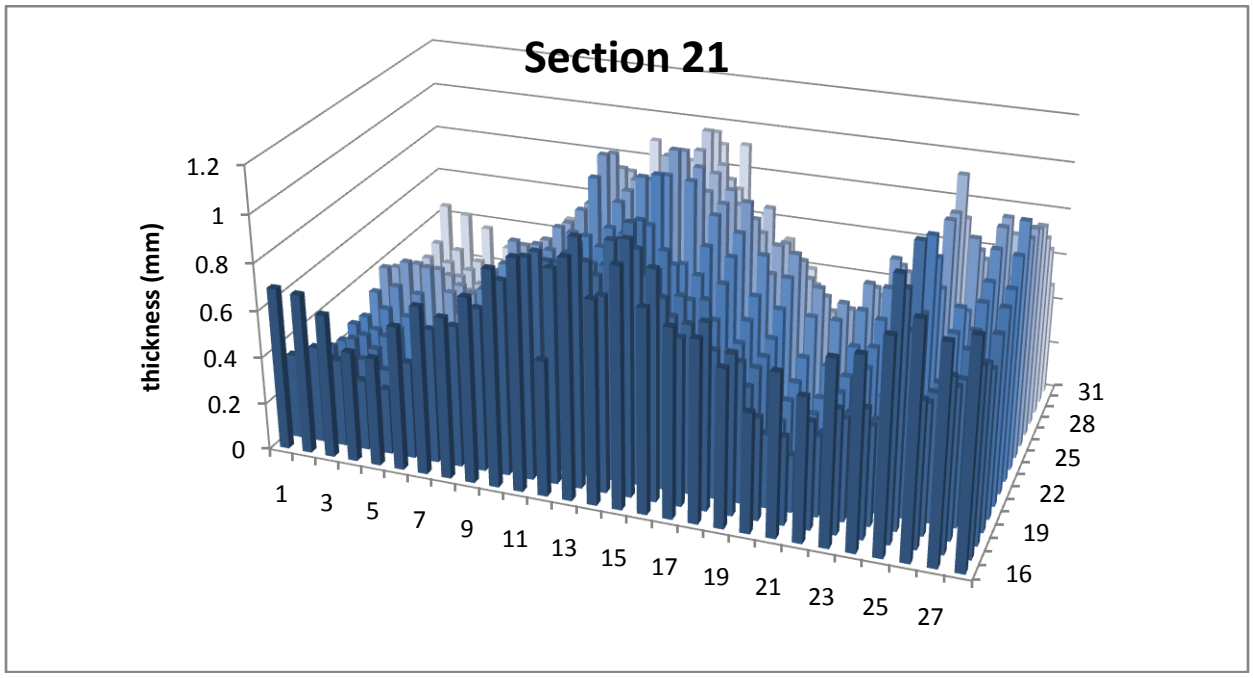


Figure: 3-D representation of Section 21 with each bar signifying the thickness of an epoxy cell; containing two vacuum lift points listed above.

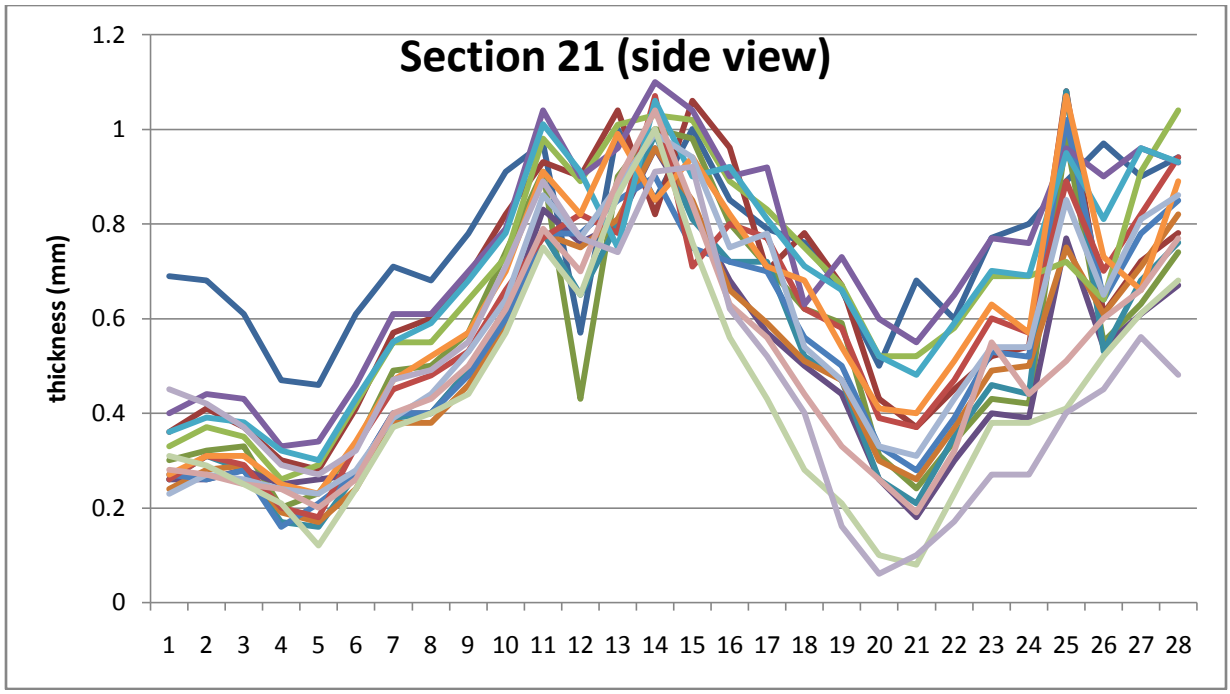


Figure: Side view of Section 21 showing the trend in thickness related to depth

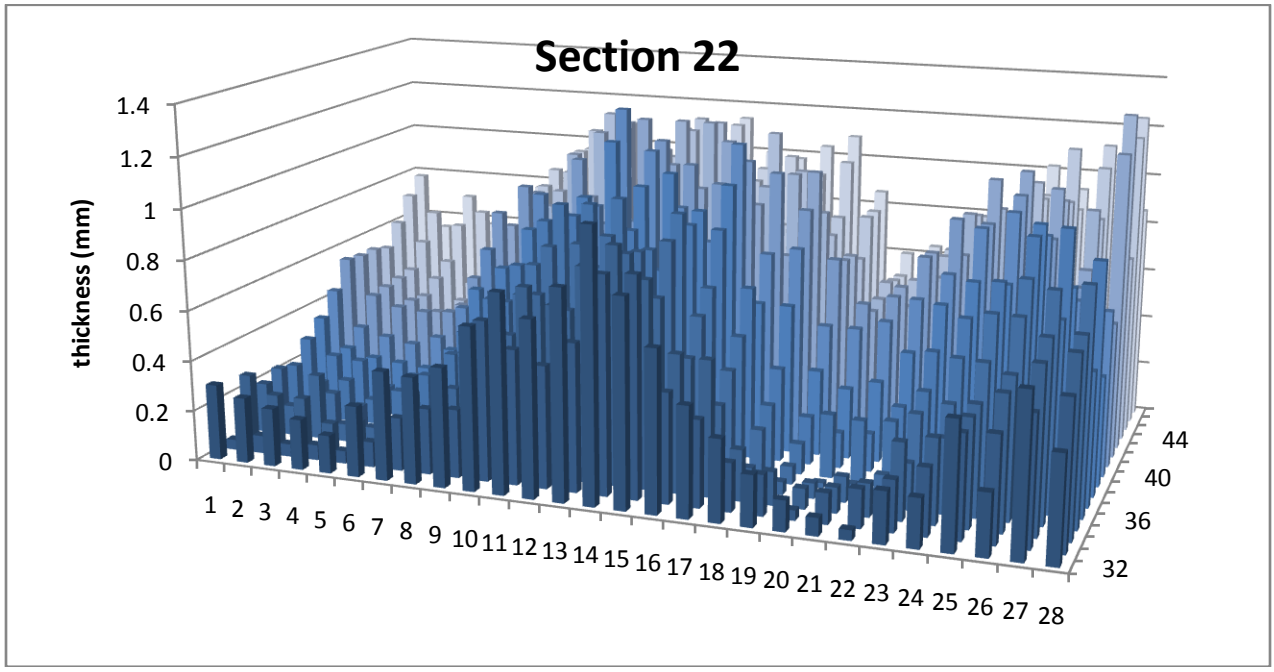


Figure: 3-D representation of Section 22 with each bar signifying the thickness of an epoxy cell; containing two vacuum lift points listed above.

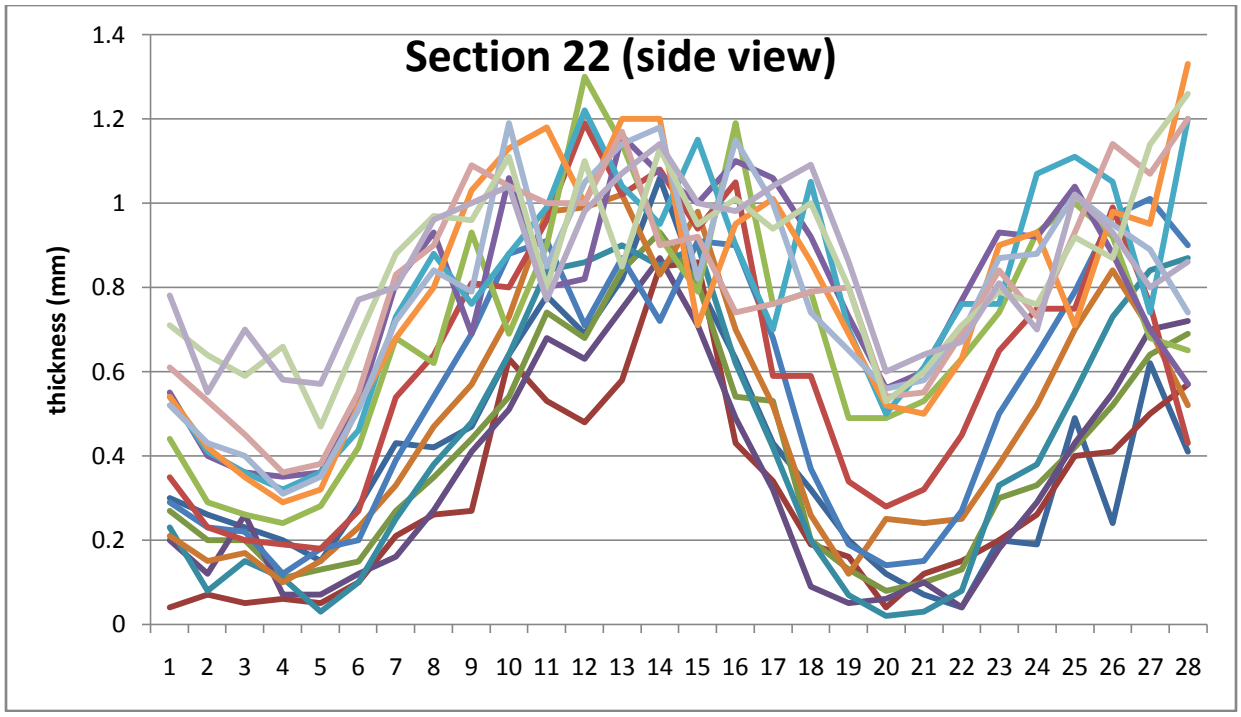


Figure: Side view of Section 22 showing the trend in thickness related to depth

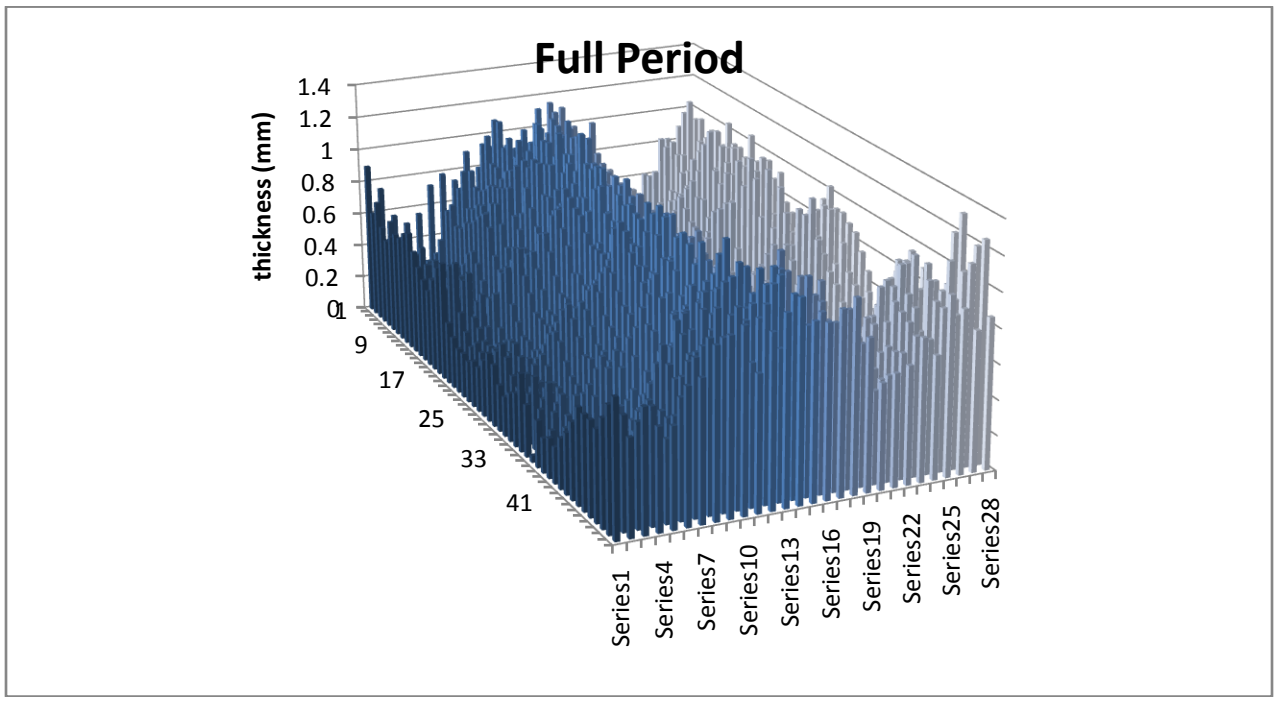


Figure: 3-D representation of all three sections

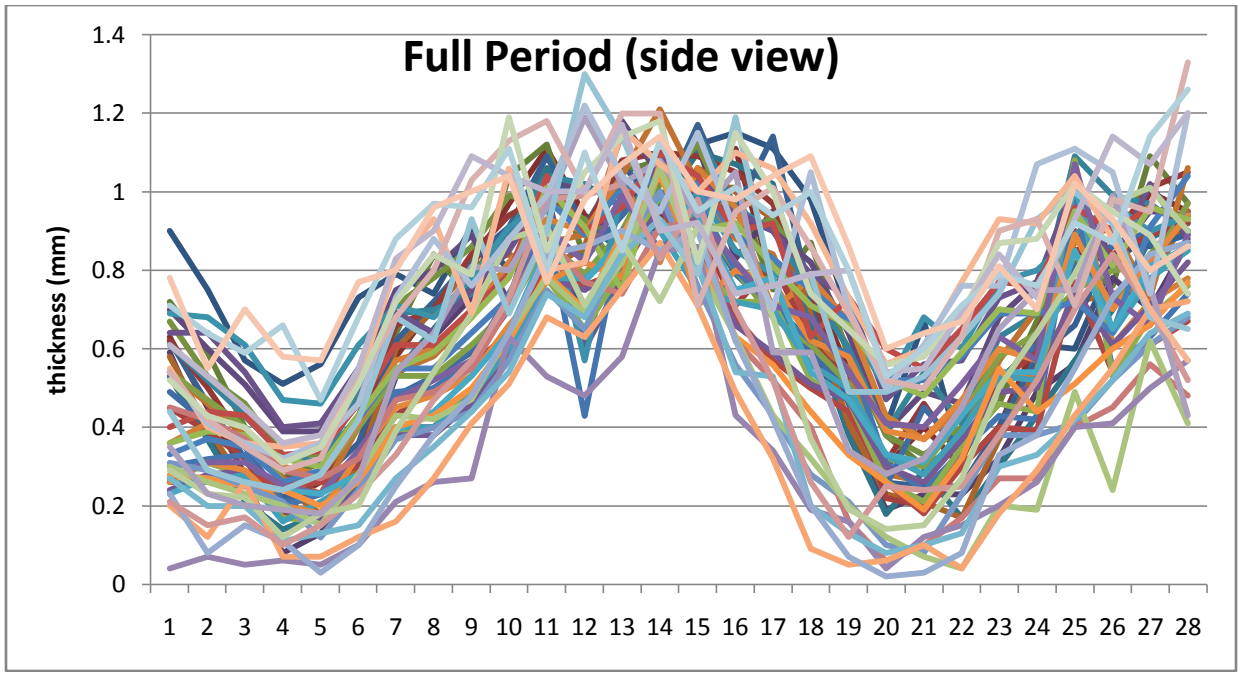


Figure: Side view of all three sections showing thickness related to depth.

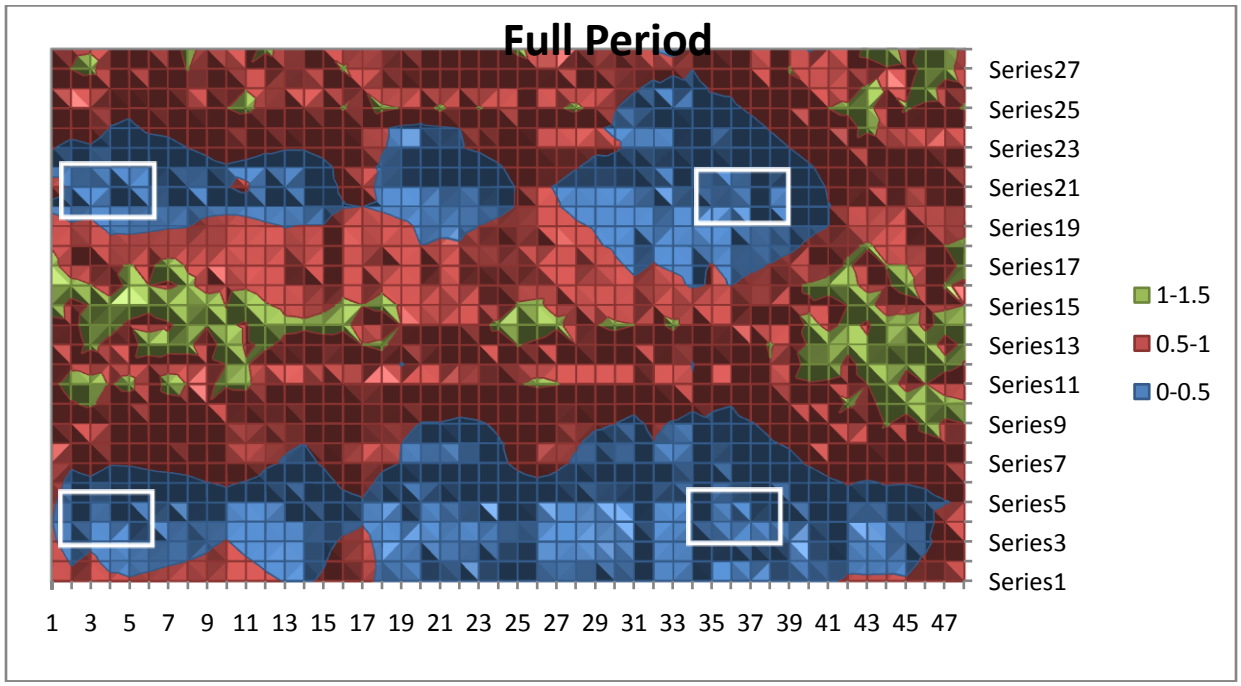


Figure: Top view of all three sections with relative color indicating thickness in mm, and vacuum lift point highlighted in white rectangles.

Conclusions sheet 2

-Average thickness of cells in full period studied: 0.625 mm

-Standard deviation of cells in full period studied: 0.284 mm

(Very high, so averages will be broken down by sections of rows related to lift positions)

-Average thickness: rows 0→8: 0.433 mm

-Average thickness: rows 9→18, and 24→27: 0.799 mm

-Average thickness: rows 19→24: 0.5 mm

-**21% of the total cells are close to optimum thickness, between 0.2 mm – 0.4 mm.**

This sheet is much thicker than the other and much further from the optimum thickness, making my hypothesis sheet 1 was pressed for an hour and sheet 2 was just placed

Also it would seem that the pressed sheet 1 would be the optimum method